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L K. Arnold

*Iowa State College*

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## EXTRACTION OF SOYBEAN OIL WITH VARIOUS SOLVENTS

L. K. ARNOLD

Volatile solvents for soybean oil have, from the standpoint of the soybean processor, two uses: in the laboratory in the determination of the oil content of the beans and in solvent types of oil extraction plants for the removal of the oil.

The usual method for the determination of oil in oil bearing seeds is by extraction with a volatile solvent in a Soxhlet or similar extractor. Ethyl ether may be used but is not very practical because of its fire hazard. Certain petroleum fractions are in more general use. For example, the American Oil Chemists Society official methods specify an initial boiling point of 35° to 38° c., dry flask end point of 52° to 60° C, 95 per cent distilling under 54°C, and not over 60 per cent under 40°C. In our laboratory we have used commercial pentane ("Skellysolve A") boiling at 28° to 38°C, commercial hexane ("Skellysolve B") boiling at 60° to 71°C, and commercial heptane ("Skellysolve C") boiling at 86° to 100°C. The heptane was rejected because of the long time required to remove it from the oil on the steam hot plate before weighing. The pentane was rejected because of the fire hazard due to its low boiling point. The hexane was adopted as a happy medium for all routine determinations. It was found that 45 minutes on the steam plate following distillation of most of the solvent from the extracted oil was sufficient to remove all solvent leaving the oil ready to weigh. Since, however, hexane is inflammable it was of interest to know what non-flammable solvents might be substituted for it which would give comparable results.

A large amount of work has been done in this laboratory on the development of solvent extraction equipment for soybean oil using trichloroethylene. It was of interest to know how efficient other chlorinated hydrocarbons might be as solvents for soybean oil. Since commercial hexane is used in most solvent extraction plants operating on soybeans it was of interest in comparison with other solvents.

With possible applications to both laboratory oil determination and commercial processing in mind a study was made of the comparative amounts of crude oil removed from soybeans by several non-flammable solvents. Since for both purposes it is desirable to have solvents with boiling points less than that of water, low boiling solvents were selected. Three of these were chlorine substitution compounds of methane: methylene chloride (dichlormethane) boiling point 39.8°C; chloroform (trichlormethane) boiling point 61.2°C; and carbon tetrachloride (tetrachlormethane) boiling point 76.5°C. Ethylene dichloride, boiling point 83.5°C, while not strictly non-flammable was added since it is available commercially in quantity and presents only a small fire hazard. Trichloroethylene, boiling point 86.9°C, is being used in this

laboratory for solvent extraction studies and presents certain technical advantages as a solvent. Commercial hexane was, although flammable, added for comparison purposes.

The extraction was in standard medium sized Soxhlet extractors heated by electric hot plates. The extraction time was 105 minutes with about two minutes to each cycle. Most of the solvent was distilled off after extraction on an electric hot plate. The remaining solvent was volatilized off on a steam plate. Since the chlorinated compounds are not as readily removed from the oil in this manner as hexane the samples were heated 75 minutes instead of the usual 45 minutes and reheated a second time for a check weighing after the first weighing.

Flaked, rather than finely ground, beans were used for extraction. They offer both advantages and disadvantages over ground beans for this purpose—the greatest disadvantage being difficulty in selecting samples having the same relative amounts of flakes and fines. Variations in results secured were perhaps partly due to this variation in the samples. From five to seven samples (in duplicate) were run on each solvent and averaged to minimize these variations. The average per cent oil by the various solvents was hexane, 18.3; carbon tetrachloride, 18.4; ethylene dichloride, 18.8; methylene chloride, 19.1; chloroform, 19.5; and trichloroethylene, 19.6.

The extracted oil produced by the chlorinated solvents was darker than that produced by the hexane. The solutions before distilling off the oil were not greatly different in color indicating that much of the darkening was probably caused by heating the oil to remove the solvent. It is known from other experimental work and commercial experience that it is difficult to remove solvents from the oil by direct heat alone, stripping out by steam of the last traces being desirable for the production of a light colored oil.

Sievers and McIntyre (1921) found that soybean oil extracted with carbon tetrachloride and trichloroethylene was darker than that extracted by light gasoline but showed no greater refining loss. Both soybean oil and peanut oil extracted by trichloroethylene were darker than oil extracted by other solvents but refined to give the lightest oils.

Since carbon tetrachloride gives results not appreciably different from hexane, it might be substituted in the analytical determination of the oil. However, because of the lower boiling of methylene chloride and greater ease of removal from the oil sample it seems preferable to use it. Trichloroethylene and chloroform are likewise not recommended because of the long time required to remove them from the oil.

For commercial purposes various technical considerations, such as freedom from corrosive action, indicate that trichloroethylene, methylene chloride, and ethylene dichloride are the most suitable. Of these,

the latter is not strictly non-flammable. Trichloroethylene is being applied commercially to solvent extraction of soybeans and it is possible that methylene chloride, which is practically as good a solvent and has a lower boiling point, may also be used. Availability and price may be the deciding factor between the two.

ENGINEERING EXPERIMENT STATION,  
IOWA STATE COLLEGE,  
AMES, IOWA.

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